pendently from transits of stars in the case of the double-image micrometer. Thus, in all these cases, irradiation is to be treated as an unknown quantity, affecting all observations, except those of the true black drop, and to be eliminated by suitable treatment of the measures.

The question now arises whether any other method of treatment can be applied with advantage to photographs taken with lenses of long focus; and, in the absence of conclusive experiments bearing on this point, I may content myself with remarking that, the distance of the photographic plate from the optical centre of a forty-feet lens must be determined with a probable error not exceeding 1-9000th part, or 1-18th of an inch, in order to give the scale of the photograph with the same degree of accuracy as measures of diameters which are probably liable to an error of 1-300th of the diameter of *Venus*. Looking to the great difficulty in finding the optical centre of a lens of very long focus, especially when combined with a plane reflector, and the effect of temperature, it seems to me very doubtful whether a focal distance of 40 feet can be determined within 1-18th of an inch, while there is every hope that the probable error of measures of diameter (when made by the same observer throughout) will fall well within the limit assigned. These points, can, however, only be decided by actual experiment; but it is at least open to question whether the inherent difficulties in determining the distances of the primary focus and of the photographic plate from the optical centres of the object-glass, and of the enlarging combination, are really greater in the photoheliographs used by the English, Germans, and Russians, than in the long focus instruments used by the Americans. There is, besides, this important consideration that any error in the determination of the focal length will affect all the photographs taken with the same instrument, with a corresponding systematic error; whilst measures of diameter will only give rise to casual errors.

Blackheath, 1875, *May* 13.

Förteckning öfver Rektascensionerna för 103 *Fundamentalstjernor* (*List of the Right Ascensions of* 103 *Fundamental Stars*).

By Professor Hugo Gyldén: Stockholm.

(*Abstract by Mr. Wackerbarth.*)

Professor Gyldén's object in making the calculations here described was to obtain, for the reduction of his Stockholm Observations a system of fundamental stars, whose right ascensions were determined with all possible accuracy. He refers in the beginning of the essay to two similar works; the one by Professor Newcomb, carried out by that learned and accomplished writer with his usual skill, but with somewhat unsatisfactory

results, as his right ascensions are very generally not triflingly larger than those determined by the chief European Observatories, Greenwich, Pulkowa, and Paris, owing probably to his having assigned very great weight to the Washington Observations, and excluded those of Paris altogether. If we designate Professor Newcomb's results with N, and those of the following pages by S, the following table will give an idea of the discrepancies:—

	N−S s		N−S s		N−S s
α Andromedæ	+0·031	α Hydræ	+0·007	α Herculis	+0·020
γ Pegasi	+0·030	α Leonis	+0·011	α Ophiuchi	+0·021
α Arietis	+0·030	β Leonis	+0·006	α Lyræ	+0·045
α Ceti	+0·015	α Virginis	+0·009	γ Aquilæ	+0·026
α Tauri	+0·004	α Boötis	+0·027	α Aquilæ	+0·018
β Orionis	−0·018	α^2 Libræ	+0·011	β Aquilæ	+0·034
β Tauri	+0·001	α Coronæ	+0·028	α^2 Capricorni	+0·020
α Orionis	−0·009	α Serpentis	+0·012	α Aquarii	+0·034
β Geminorum	+0·004	α Scorpii	+0·009	α Pegasi	+0·018

where the regularity of the differences show that the individual right ascensions have been very accurately determined.

The other list is that printed in the *Vierteljahrsschrift* (Quarterly Journal) of the German Astronomical Society. It is based on Greenwich, Paris, and Pulkowa observations, and the individual right ascensions are determined with great accuracy. The equinoxial point is less certain, being based only on Pulkowa observations of 30 years ago. To reduce the observations to 1875, it was necessary, for obtaining the proper motions, to make use of Bradley's Catalogue of 1755, so that whatever error Bradley may have committed in his determination of the equinox will enter here with one-third of its amount. Nevertheless, Dr. Gyldén's calculations show, that these absolute right ascensions are remarkably near the truth. It is of course to be supposed, that this system will harmonize very closely with that of Pulkowa when the latter is reduced to 1875; and as such it is here denoted by P.

With this and with each other the determinations of Greenwich, Paris, and Washington have been compared as follows:—

1°, *Greenwich.* The Catalogues appended to the Greenwich Observations from 1865 to 1869 inclusively have been employed, and the positions reduced to 1875 with Bessel's Precessions, and Mädler's Proper Motions. The means of the results have been considered as the definitive Greenwich positions, and are distinguished here by the letter G.

2°, *Paris.* The Paris positions are taken from the *Annales de l'Observatoire de Paris*, 1863–7, reduced to 1875; the means of these being taken are here marked Pa. But as the equinoxial point is not determined in these volumes, the constant quantity

$0^s.016$, deduced from the Paris Observations 1856-9,* has been added to all the Pa. right ascensions; and the thus amended results called Pa_1.

3°, *Washington.* The Washington positions are those given in Professor Newcomb's Appendix III., to the Astronomical Observations of 1867, reduced, with the above-mentioned precession and proper motion, to 1875; and are here distinguished by the letter W.

The mean of the differences of these systems for each hour of right ascension being taken, † and the differences themselves being considered as small quantities whose products and higher powers may be neglected, a trigonometrical formula of interpolation in which terms with arguments exceeding 2α could be rejected was formed. The result is—

$$\begin{aligned}
G-P &= -0^s.002 - 0^s.009.\cos\alpha - 0^s.007.\sin\alpha - 0^s.001.\cos 2\alpha - 0^s.002.\sin 2\alpha \\
G-Pa_1 &= +0^s.005 + 0^s.002.\cos\alpha - 0^s.015.\sin\alpha - 0^s.002.\cos 2\alpha - 0^s.002.\sin 2\alpha. \\
G-W &= -0^s.045 - 0^s.012.\cos\alpha + 0^s.009.\sin\alpha - 0^s.014.\cos 2\alpha + 0^s.001.\sin 2\alpha.
\end{aligned}$$

Adding to these the identity, $G-G = 0$, and putting

$$S = \frac{1}{4}\{G+P+Pa_1+W\},$$

we obtain

$$G-S = -0^s.010 - 0^s.005.\cos\alpha - 0^s.003.\sin\alpha - 0^s.004.\cos 2\alpha - 0^s.001.\sin 2\alpha;$$

which, combined with the preceding, gives

$$\begin{aligned}
S-G &= +0^s.010 + 0^s.005.\cos\alpha + 0^s.003.\sin\alpha + 0^s.004.\cos 2\alpha + 0^s.001.\sin 2\alpha. \\
S-P &= +0^s.008 - 0^s.004.\cos\alpha - 0^s.004.\sin\alpha + 0^s.003.\cos 2\alpha - 0^s.001.\sin 2\alpha. \\
S-Pa_1 &= +0^s.015 + 0^s.007.\cos\alpha - 0^s.012.\sin\alpha + 0^s.002.\cos 2\alpha - 0^s.001.\sin 2\alpha \\
S-W &= -0^s.035 - 0^s.007.\cos\alpha + 0^s.012.\sin\alpha - 0^s.010.\cos 2\alpha + 0^s.002.\sin 2\alpha.
\end{aligned}$$

The Melbourne Observations have been also taken into account, although these are not strictly absolute determinations, as they are based on the equinoxial point adopted in the *Nautical Almanac*. Denoting them with M, we have

$$\begin{aligned}
G-M &= +0^s.026 + 0^s.007.\cos\alpha - 0^s.028.\sin\alpha - 0^s.005.\cos 2\alpha + 0^s.002.\sin 2\alpha. \\
S-M &= +0^s.036 + 0^s.012.\cos\alpha - 0^s.025.\sin\alpha - 0^s.001.\cos 2\alpha + 0^s.003.\sin 2\alpha.
\end{aligned}$$

The right ascensions in the four systems G, Pa_1, W and M having been amended by means of the above formulæ, the separate means were taken, and the following right ascensions were the result:—

* *Vide* Nyrén's *Försök till Bestämning af Precessionskonstanten. Uppsala*, 1869, p. 30.

† The numbers in the *Vierteljahrsschrift* have been *here* employed only to ascertain the systematic differences of different lists.

	h	m	s		h	m	s
α Andromedæ	0	1	55·733	ε Hydræ	8	40	9·339
γ Pegasi	0	6	48·012	83 Cancri	9	12	0·152
12 Ceti	0	23	39·565	α Hydræ	9	21	26·80
β Ceti	0	37	18·830	ε Leonis	9	38	45·162
ε Piscium	0	56	27·415	π Leonis	9	53	36·394
θ Ceti	1	17	46·536	α Leonis	10	1	42·799
η Piscium	1	24	47·765	γ Leonis	10	13	4·687
υ Piscium	1	34	55·632	ρ Leonis	10	26	13·662
8 Arietis	1	47	44·232	l Leonis	10	42	41·136
α Arietis	2	0	7·773	χ Leonis	10	58	34·075
67 Ceti	2	10	44·937	δ Leonis	11	7	27·507
ξ Ceti	2	21	30·855	δ Crateris	11	13	5·539
γ Ceti	2	36	49·486	υ Leonis	11	30	32·912
α Ceti	2	55	44·779	β Leonis	11	42	40·957
δ Arietis	3	4	29·004	η Virginis	12	13	30·647
η Tauri	3	40	3·365	γ^1 Virginis	12	35	19·585
γ Eridani	3	52	11·849	12 Canum Venat.‡	12	50	10·680
o′ Eridani	4	4	45·872	θ Virginis	13	3	28·741
ε Tauri	4	21	19·136	α Virginis	13	18	36·564
α Tauri	4	28	44·959	ζ Virginis	13	28	19·488
ι Aurigæ	4	48	51·305	η Boötis	13	48	43·965
ε Leporis	5	0	10·217	τ Virginis	13	55	17·146
8 Orionis	5	8	31·880	α Boötis	14	9	57·606
β Tauri	5	18	23·464	ρ Boötis	14	26	26·573
δ Orionis	5	25	37·299	ϵ^2 Boötis	14	39	31·665
α Leporis	5	27	13·074	α^2 Libræ	14	43	57·924
ε Orionis	5	29	52·278	ψ Boötis	14	59	5·374
α Orionis	5	48	24·291	β Libræ	15	10	16·924
ν Orionis	6	0	26·102	α Coronæ	15	29	23·740
μ Geminorum	6	15	23·907	α Serpentis	15	38	6·707
γ Geminorum	6	30	29·418	β^1 Scorpii	15	58	10·242
γ Canis Majoris	6	58	6·230	δ Ophiuchi	16	7	47·777
δ Geminorum	7	12	39·393	α Scorpii	16	21	44·721
α Geminorum	7	26	37·297	ζ Herculis	16	36	34·514
β Geminorum	7	37	39·890	κ Ophiuchi	16	51	45·101
6 Cancri	7	55	50·323	α Herculis	17	8	56·886
η Cancri	8	25	28·692	θ Ophiuchi	17	14	20·025

‡ In years subsequent to 1870 this star is in the *Nautical Almanac* called α *Canum Venaticorum.*

	h	m	s		h	m	s
α Ophiuchi	17	29	7·939	61^1 Cygni	21	1	17·653
μ Herculis	17	41	34·007	ζ Cygni	21	7	36·990
μ Sagittarii	18	6	17·250	β Aquarii	21	24	58·644
α Lyræ	18	32	42·352	ϵ Pegasi	28	38	2·782
β Lyræ	18	45	27·877	16 Pegasi	21	47	22·498
ζ Aquilæ	18	59	39·858	α Aquarii	21	59	21·772
ω Aquilæ	19	11	56·920	θ Aquarii	22	10	14·053
δ Aquilæ	19	19	11·715	η Aquarii	22	28	55·943
h^2 Sagittarii	19	29	5·918	ζ Pegasi	22	35	13·648
γ Aquilæ	19	30	18·999	α Pegasi	22	58	32·102
α Aquilæ	19	44	41·052	γ Piscium	23	10	41·104
β Aquilæ	19	49	10·360	κ Piscium	23	20	31·486
α^2 Capricorni	20	11	7·070	ι Piscium	23	33	31·288
ρ Capricorni	20	21	43·710	ω Piscium	23	52	53·558
32 Vulpeculæ	20	49	13·953				

These positions have a probable error of only $\pm 0^s{\cdot}007$, or when we include the systematic uncertainty arising from differences in the constant terms $\pm 0^s{\cdot}009$, so that their accuracy may be said to be $0^s{\cdot}01$.

The following is a comparison of them with the list in the *Vierteljahrsschrift*, the *Nautical Almanac*, and the *Berliner Jahrbuch*:—

Star.	S.−P.	S.−*N.A.*	S.−*B.J.*
α Andromedæ	+0·007	+0·004	+0·008
γ Pegasi	−0·012	−0·004	−0·080
12 Ceti	−0·025	+0·041	
β Ceti		+0·053	0·000
ϵ Piscium	+0·002	−0·038	
θ Ceti	0·000	+0·065	
η Piscium	−0·028	+0·014	
ν Piscium	−0·023	+0·063	
β Arietis	+0·004	+0·077	
α Arietis	−0·006	+0·018	−0·046
67 Ceti	−0·007	+0·043	
ξ^2 Ceti	+0·027	+0·028	
γ^2 Ceti	−0·005	+0·028	
α Ceti	+0·015	+0·032	−0·007
δ Arietis	−0·033	0·000	−0·117
η Tauri	+0·011	+0·008	
γ Eridani		+0·041	

Star.	S.−P.	S.−*N.A.*	S.−*B.J.*
o^1 Eridani	−0·025	+0·078	
ϵ Tauri	−0·002	+0·041	
α Tauri	+0·005	+0·007	−0·034
ι Aurigæ	+0·011	+0·028	
ϵ Leporis		+0·078	
β Orionis	+0·004	+0·054	−0·036
β Tauri	+0·004	−0·035	−0·028
δ Orionis	−0·023	+0·041	
α Leporis		+0·034	
ϵ Orionis	−0·013	+0·074	
α Orionis	+0.001	+0·011	−0·067
ν Orionis	−0·028	+0·003	
μ Geminorum	−0·002	−0·001	
γ Geminorum	−0·002	+0·018	
γ Canis Majoris		+0·012	
δ Geminorum	0·000	−0·039	
α^2 Geminorum		−0·056	+0·251
β Geminorum	+0·010	+0·005	−0·032
6 Cancri	+0·021	+0·051	
η Cancri	−0·010	+0·034	
ϵ Hydræ	+0·006	+0·021	
83 Cancri	−0·035	+0·042	
α Hydræ	+0·005	+0·040	−0·031
ϵ Leonis	0·000	−0·048	
π Leonis	−0·008	0·000	
α Leonis	+0·014	+0·001	0·015
γ^1 Leonis		−0·016	−0·025
ρ Leonis	+0·049	−0·051	
l Leonis	−0·004	+0·034	
χ Leonis	−0·020	−0·002	−0·124
δ Leonis	+0·036	−0·025	−0·137
δ Crateris		+0·012	−0·070
υ Leonis	+0·014	+0·040	
β Leonis	+0·015	+0·012	−0·028
η Virginis	+0·020	+0·032	
γ^1 Virginis	−0·032		
12 Canum Venat.	+0·035	+0·021	
θ Virginis	−0·003	+0·029	
α Virginis		+0·048	−0·023

Star.	S.−P.	S.−*N.A.*	S.−*B.J.*
ζ Virginis	+0·022	+0·002	−0·151
η Boötis	+0·010	−0·030	−0·149
τ Virginis	+0·018	−0·002	
α Boötis	+0·011	−0·024	−0·015
ρ Boötis	+0·013	−0·009	
ϵ^2 Boötis		−0·010	
α^2 Libræ		0·000	−0·023
ψ Boötis	−0·011	−0·030	−0·048
β Libræ	+0·001	+0·045	
α Coronæ	+0·001	−0·029	−0·050
α Serpentis	+0·018	+0·008	−0·027
β^1 Scorpii		+0·016	
δ Ophiuchi	−0·006	+0·070	
α Scorpii		+0·012	−0·010
ζ Herculis	+0·004	+0·017	−0·162
κ Ophiuchi	+0.037	+0·040	+0·019
α Herculis	−0·005	+0·002	−0·062
θ Ophiuchi		+0·022	
α Ophiuchi	+0·016	+0·040	−0·013
μ Herculis	−0·003	−0·005	+0·038
μ^1 Sagittarii		+0·056	
α Lyræ	−0·023	−0·020	−0·050
β Lyræ	+0·031	−0·009	−0·011
ζ Aquilæ	+0·021	+0·051*	
ω Aquilæ	−0·007	+0·028	
δ Aquilæ	−0·004	+0·054	+0·003
h^2 Sagittarii		+0·068	
γ Aquilæ	−0·013	−0·017	−0·046
α Aquilæ	−0·008	+0·009	−0·052
β Aquilæ	−0·012	+0·008	−0·062
α^2 Capricorni		+0·060	−0·027
ρ Capricorni		+0·064	
32 Vulpeculæ		−0·009	
61^1 Cygni	+0·006	+0·129	+0·128
ζ Cygni	−0·081	+0·026	
β Aquarii	−0·001	+0·071	

* The difference between the R.A. given and that of the *Nautical Almanac* is $0^s·061$; but whether the misprint is here or in the list of Right Ascensions, I am unable to say.

Star.	S.−P.	S.−*N.A.*	S.−*B.J.*
ϵ Pegasi	+0·008	−0·040	
16 Pegasi	+0·008	−0·031	
α Aquarii	−0·006	+0·066	−0·052
θ Aquarii		−0·084	
η Aquarii	+0·028	+0·058	
ζ Pegasi	+0·019	+0·044	
α Pegasi	−0·021	+0·027	−0·039
γ Piscium	+0·016	+0·040	+0·018
π Piscium	−0·010	+0·050	
ι Piscium	−0·002	+0·042	−0·119
ω Piscium	+0·025	+0·006	−0·076

The errors of the press in Professor Gyldén's essay are very numerous; those which I have observed I have corrected, where I have had the means of doing so.

Uppsala, 1875, *May* 1.

On the Proper Motion of the Star in Cetus, marked 793 *in the British Association Catalogue.* By C. Piazzi Smyth, Astronomer Royal for Scotland.

In the course of preparing the forthcoming Edinburgh Catalogue of Stars (intended chiefly to illustrate Proper Motion and facilitate its further observation), the most interesting case that I have yet come across is the small 6·5 mag. star in *Cetus*, numbered 793 in the British Association Catalogue, and otherwise known as Piazzi II. 123; Taylor II. 268; W. 156; and Weisse II. 464.

It is interesting, not only from the proper motion being large in both elements of place, but from its undergoing undoubted variations with time; and also from its catalogue-history having chanced to render it a luminous example of the importance of the modern method of accompanying the one general date of the epoch of any Catalogue by the particular dates of the observations concerned with each star; as well as with the amount of precession and other quantities actually employed in reducing the Stars' places from their dates of observation to the date of the Catalogue.

The place of the star in the B.A.C. for 1850 is,

$$\text{R.A.} = 2^{h}\ 27^{m}\ 51^{s}\cdot35 \quad \text{and} \quad \text{N.P.D.} = 83^{\circ}\ 50'\ 0''\cdot2$$

the former being $0^{s}\cdot50$ in defect, and the latter $5''\cdot2$ in excess, according to the Edinburgh observations; and the star was